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407-89GB

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The Patent Office

Request for grant of a Patent

Form 1/77

Patents Act 1977

❶ Title of invention

1 Please give the title of the invention

BLADDER PUMP FOR BOREHOLE SAMPLING

❷ Applicant's details

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please give details below

Agent's name Anthony ASQUITH

Agent's address 328 Leeds Road, Scholes
LEEDS LS15 4DD
England

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Agent's ADP number 02657096003

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⑤ Claiming an earlier application date

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Country of filing	Priority application number *(if known)*	Filing date *(day, month, year)*
Britain	0301936.1	28 January 2003

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⓼ *Please supply duplicates of claim(s), abstract, description and drawing(s).*

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8a Please fill in the number of sheets for each of the following types of document contained in this application.

Continuation sheets for this Patents Form 1/77	
Claim(s)	2
Description	8
Abstract	1
Drawing(s)	5

8b Which of the following documents also accompanies the application?

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Priority documents *(please state how many)*	
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Duplicate

Title: BLADDER PUMP FOR BOREHOLE SAMPLING

[001] This invention relates to bladder pumps, of the kind as used when extracting a sample of e.g water from a well or other borehole in the ground.

BACKGROUND TO THE INVENTION

[002] In a conventional bladder pump, a bladder of flexible material is provided with check valves above and below. The pressure inside the bladder is controlled from the surface, the bladder being surrounded by an annular chamber having a pressure-control line to the surface.

[003] When the pressure inside the bladder is reduced to a level below the hydrostatic pressure in the borehole, water enters the bladder through the bottom check-valve. When the bladder is pressurised, the bottom check-valve closes; the increased pressure drives the water up though the upper check-valve, and to the surface, via a sample-transfer pipe.

[004] Thus, sample water from the borehole can be transferred to the surface by controlling the pressure in the annular chamber, i.e by alternately increasing and decreasing that pressure to values above and below the hydrostatic pressure in the borehole.

[005] The bladder comprises a length of thin-walled plastic tubing. This tubing is so flimsy that the tubing can readily expand and collapse. However, one of the key aspects with which the designer must be concerned is the manner by which the bladder is to be attached to the stems of its hard (metal or plastic) end fittings. The manner of attachment must be secure against mechanical forces tending to pull the bladder off the stem, and also the attachment must be done without stressing the thin flimsy plastic material, and causing it to tear.

[006] Traditionally, bladder pumps have not been successful at small diameters. Designing a reliable manner of attaching a tube of thin flimsy plastic to a hard metal end-fitting is difficult enough when the tube is e.g twenty mm in diameter. There is a need, however, for bladder pumps having diameters in the region of six mm. The invention is aimed at providing a manner of attaching such a small-diameter tube of flimsy material to an end-fitting.

[007] One of the aspects that must be addressed by the designer of a sampling pump is the fact that boreholes in the ground are rarely straight. Thus, the tube(s) leading down to the pump from the surface must be flexible in the sense of being able to follow the non-straightness of the borehole without becoming jammed. However, when the diameter of

the pump was large, the designer could make the pump body quite short, lengthwise (i.e vertically), and thus the pump body could be of rigid material, and still follow the non-straightness.

[008] But when the diameter of the bladder is small, now the bladder needs to have substantial length (longer than e.g about sixty cm) in order for the volume of the bladder to be adequate, and now a rigid pump body would become jammed because of the non-straightness of the borehole. With a more-than-sixty-cm-long pump body, the designer will prefer to specify that the pump body be of (slightly) flexible plastic, rather than of metal. Of course, the plastic pump body is still many orders more rigid than the flimsy tubing of the bladder.

[009] It has also been traditional, in bladder pumps, for a spine to be included inside the bladder, to keep the bladder to its shape and prevent it collapsing. The new design as described herein reduces the need for such a spine.

GENERAL FEATURES OF THE INVENTION

[0010] The invention provides a way of securing a flimsy bladder tube around and to a rigid stem. The new invention makes use of a spring, i.e a helical or coil spring. The bladder tube fits over the stem, and then the spring fits over the (thin) wall of the tube, and the spring compresses the wall of the tube onto the stem. It has been found that a bladder tube secured in this manner can resist high pressures, and has little tendency to become torn at the point of attachment, even though subjected to frequent flexure.

[0011] The spring clamps at each end of the flexible bladder are fabricated from small diameter stainless steel coil springs. The end-fitting itself has a stem or mandrel onto which a helix (screw-thread) is formed. Preferably, the pitch of the helix is slightly larger than the pitch of the spring, as this provides preload of the spring upon assembly.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0012] By way of further explanation of the invention, exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:
Fig 1 shows a length of bladder tube for a bladder pump, about to be secured to an end fitting, in the manner of the invention.
Fig 2 is the same as Fig 1, but shows the components at a later stage of securement.
Fig 3 is the same as Fig 1, but at a still later stage.
Fig 4 is an enlarged detail of a portion of Fig 3.
Fig 5 is a cross-section of a completed bladder, assembled into the bladder pump.
Fig 6 shows a pressure control unit located at the ground surface, for use in operating the

pump.

Fig 7 is a similar cross-section to Fig 5, but shows an alternative construction.

Fig 8 is a cross-section that shows a modified component of a bladder pump.

[0013] The apparatuses shown in the accompanying drawings and described below are examples which embody the invention. It should be noted that the scope of the invention is defined by the accompanying claims, and not necessarily by specific features of exemplary embodiments.

[0014] To assemble the bladder retention system, bladder tube 20 is first collapsed in such a manner as to allow helical coil spring 23 to pass over and along the tube, to a position approximately two cm from the end of the tube. This condition is shown in Fig 1. The bladder tube 20 has substantially no inherent rigidity, being of thin-walled (typically, in the region of 0.1 mm wall thickness) heat-shrinkable polytetrafluoroethylene (ptfe).

[0015] The stem 24 of the (stainless steel) upper end-fitting 25 is formed with a shallow single-start-helical groove 26. The groove is e.g 0.02 mm deep. The groove profile is gently rounded, such that the wall of the bladder tube, upon being squeezed into intimate touching contact with the stem, leaves no gaps (potential leakage paths) in the profile.

[0016] The open end of the bladder tube 20 is placed over the stem 24. The end portion 27 of the bladder tube is heated, whereupon the ptfe material shrinks, such that, over a heat-shrunk area 28, the bladder tube now conforms to, and grips lightly around, the stem 24, being the condition as shown in Fig 2. As shown, the heat-shrunk area 28 of the bladder tube extends a little way past the stem.

[0017] The spring 23 is drawn forwards, over the heat-shrunk area 28, and threaded over the stem 24. The dimensions of the components are such that the spring 23 has to be expanded slightly in order for the spring to be screwed onto the groove 26, over the thickness of the ptfe material. The result is as shown in Fig 3, and in detail in Fig 4. This operation can be carried out by a person, by the use of the fingers (although the assembly may be automated).

[0018] Heat-shrunk thin-walled ptfe tubing can be held very securely to the stem of the end-fitting by this technique. The manner of securement imposes very little stress-concentration in the flimsy bladder material, although care should be taken to ensure that particularly the end of the stem is smooth and rounded. The manner of securement has been found to be mechanically strong, and more than adequate both against forces tending to pull the bladder tube axially off the stem, and against pressure forces, internally and externally of the bladder.

[0019] In use for extracting samples from boreholes, the bladder may be subjected to a

pressure differential in which the pressure outside the bladder exceeds the pressure inside by around 10 psi, and a reverse differential also of around 10 psi.

[0020] The other end of the bladder tube 20 is secured to the stem 29 of the bottom end fitting 30 by the same technique.

[0021] As shown in Fig 5, the assembled bladder 32 is placed inside an outer pump tube 34. The outer pump tube 34 is of thick-walled polyethylene or ptfe, having a wall thickness of around 1.5 mm. The tube 34 is inherently self-supporting, being much thicker and stiffer than the (flimsy) bladder tube 20. Such plastic tubing is flexible, however, in the sense that the tubing can be bent to a (gentle) arc, which is what is needed if the bladder pump is to be fed through tight narrow clearances -- given that drilled boreholes in the ground and the pipes and tubes used therein are usually not quite straight. The plastic outer pump tube 34, however, is rigid when it comes to resistance to pressure, i.e in the sense of resistance to hoop or circumferential stresses. Pressure differentials to be supported by the outer pump tube would typically be around 100 psi, which the described kind of tubing can support.

[0022] Alternatively, the outer pump tube can be made of metal or more rigid plastic.

[0023] The bottom end fitting 30 of the bladder 32 includes the barbed stem 29, to which the lower end of the pump outer tube 34 is secured. The bottom end fitting 30 includes a check valve in the form of a (stainless steel) ball 36, which settles against a seat 37 if pressurised from above, and allows fluid to pass through the fitting 30 if pressurised from below.

[0024] The upper end fitting 25 of the bladder includes a long-tube 38, which fits inside the central bore 39 of an outer adapter piece 40. The long-tube 38 is a loose fit inside the adapter 40, and is not attached to the adapter. A shoulder 42 on the upper end fitting 25 limits the extent to which the long-tube 38 can travel upwards into the adapter 40. The shoulder 42 is angled to ensure that, even if the shoulder were in contact with the lower end-face 41 of the adapter 40, fluid can pass freely, past the shoulder 42, around the long-tube 38, and through the bore 39.

[0025] The upper end of the long-tube 38 is barbed to receive the sample transfer tube 43, which is a length of thick-walled polyethylene tubing that extends to the surface. The bottom end of the sample transfer tube 43 is fitted with a check-valve. A collar 46 is first inserted into the sample transfer tube 43. This collar grips the tube 43 internally. A stainless steel ball 47 provides the check-valve function, in combination with a suitable valve-seating provided in the top end-face of the long-tube 38. The collar is angled as to its bottom end-face, which is so arranged that the ball cannot seal thereagainst.

[0026] Alternatively, the ball may be replaced by a valve member of another shape. The

check-valve function requires that the valve should seal when pressurised from above, but should be open when pressurised from below.

[0027] When the sample transfer tube 43 is barbed to the upper end of the long-tube 38, the valve member 47 is trapped thereinside.

[0028] In an alternative construction, the check valve is built into a housing that is screwed onto the top end of the long-tube. The sample transfer tube, in that case, is barbed to the upper end of the housing.

[0029] The sample transfer tube 43 being now barbed onto the long-tube 38, the down-hole portion of the pump assembly is completed by barbing outer tube 49 onto the upper end of the adapter piece 40. The outer tube 49 extends up to the surface.

[0030] In Fig 5, the long-tube 38 can float, vertically, inside the adapter 40. The long-tube is limited as to its upwards movement by the engagement of the angled shoulder 42 with the bottom end-face 41 of the adapter, and is limited as to its downwards movement by the engagement of the bottom end of the barbed-on sample-transfer tube 43 with the upper end-face 44 of the adapter.

[0031] At the surface, as shown in Fig 6, a manifold 50 is provided. The sample transfer tube 43 passes right through the manifold, for conveying the sample to a suitable receptacle at the surface. The outer tube 49 communicates with the drive port 53, through which the annular space 54 between the outer tube 49 and the sample transfer tube 43 can be pressurised (with gas). The annular space 54 communicates with the space 56 between the bladder tube 20 and the pump outer tube 34. By pressurising this space 56 (i.e by pressurising the space 54), the bladder 32 can be made to collapse.

[0032] In use, the drive port 53 is alternately pressurised and de-pressurised. When the space 56 is de-pressurised, the bottom check valve opens and water from the borehole enters the bladder 32. The upper check valve opens also if the pressure in the sample transfer tube 43 is below the borehole pressure of the sample of water entering the bladder.

[0033] Next, the space 56 is pressurised, which causes the bladder to collapse. The bottom check valve closes, and the upper check valve opens, and the sample is pumped out of the bladder, upwards into the sample transfer tube 43. By raising and lowering the pressure supplied to the port 53, water can be pumped out of the borehole, and into the surface receptacle.

[0034] It will be noted that the bladder 32 is mechanically attached to the pump outer tube 34 at the very bottom of the pump, and the sample transfer tube 43 is attached to the manifold 50 at the sampling port 52. Apart from those attachment points, the sub-

assembly of the bladder 32 and the sample transfer tube 43 is free to float in the space inside the outer tubes 34,49 and inside the adapter 40. This free floating aspect is important in avoiding unpredictable stresses in the flimsy material of the bladder tube 20, and in permitting the pump, as an assembled structure, to be flexible enough to pass freely up and down the narrow and not-quite-straight passageways.

[0035] It has been found that, when the coil spring 23 is screwed onto the stem, trapping the ptfe tubing 20 therebetween, the tubing does not tend to become twisted. That is to say, the tubing remains fixed to the stem 24, and the spring rotates around the tubing. In fact, the tubing is so flimsy that, if the tendency were for the tubing to be dragged around with the spring, not much could be done e.g by way of gripping the tubing, to resist that tendency.

[0036] Assembly of the bladder itself is simple enough, at least as a manual operation, in that the bladder (i.e the bladder tube and its two end fittings) is completed as a unit before the bladder is assembled into the outer tube. Of course, some care is needed when carrying out assembly work on the bladder, as it is all too easy to damage the thin-walled tubing.

[0037] Fig 7 shows an alternative design. Here, the adapter 40 has been omitted, and the pump outer tube 34 and the outer tube 49 are one and the same. Now, the bladder upper end fitting 60 is completely floating inside the outer tube 62. This arrangement is simpler than that of Fig 5, and can be suitable for shallow boreholes.

[0038] The problem of attaching a flimsy tube to a stem, in a manner that leaves the attachment mechanically strong, and pressure-resistant, is exacerbated when the overall diameter of the tube is very small. In the case as depicted in the drawings, the ptfe heat-shrinkable tubing from which the bladder is made is six mm in diameter. The stem onto which the heat-shrunk end of the bladder tube is secured is nominally 4.5 mm in diameter. The coil spring is made of round wire, of ¾ mm diameter, and is about seven coils in length. It is wound to a helix of such diameter that, if the bladder tube 20 were not present, the spring would just about slide axially over and along the stem.

[0039] Attaching a six mm diameter ptfe tube to a stem, in a manner which leaves the attachment able to resist quite high pressures, and to resist continual flexing of the tube wall, is a difficult problem. Properly serviceable bladder pumps are readily available in sizes above about fifteen mm bladder diameter, but traditionally, below that diameter, the pumps that have been available have been notoriously fragile, and prone to leakage and other problems. The manner of attaching the bladder as described herein may be expected to alleviate the robustness problems.

[0040] The reduced diameter of the pump of course means that, in order to achieve good sample volumes, the bladder must be quite long. Thus, where a fifteen mm bladder pump

may be say sixty cm long, the six mm bladder pump preferably is 1.5 metres long. The long length of the bladder means that the difference between the inside/outside pressure differential at the top of the bladder can be a significantly larger than the differential at the bottom of the bladder. Thus, the bladder in a long, small-diameter pump is called upon to support greater differentials than the bladder in a shorter, larger-diameter pump. Even so, the manner of attachment as described herein is more than adequately equal to the task.

[0041] The designer may specify that the space 56, and the space 54, be partially filled with water or other liquid. This can assist in reducing pressure differentials between the insides of the tubes 43,20 and the spaces 54,56 without affecting pump operability.

[0042] In the larger diameters of bladder, the task of screwing a coil spring over tubing, over a stem, becomes a little more difficult, and, as mentioned, traditional ways of attaching thin-walled tubes to stems are acceptable when the diameter is large. However, the technique of the screwed-on coil spring over heat-shrunk tubing, as described, may be used in the larger diameters.

[0043] Because of the small volume of a small-diameter bladder, it can sometimes be a problem to extract samples at a high flowrate, where that is a requirement. In that case, several bladders may be provided. The several bladders are separately operated (by being pressurised from above), but all the bladders discharge into a common sample transfer tube leading to the surface. Several independent small-diameter bladder pumps can be more flexible, and easier to lower down to deep depths, than one large-diameter pump.

[0044] Fig 8 shows a modification to the manner in which the long-tube 38 of Fig 5 interacts with the adapter 40. A problem that can happen in Fig 5 arises from the fact that plastic tube is usually transported and stored in coils. Stored thus, the tubing takes on a set to the curvature.

[0045] Thus, the outer tube 49 (and the outer pump tube 34) can have acquired a slight curvature. The outer tube might be dozens (sometimes hundreds) of metres long, whereby the bottom end of the tube can easily lie slightly twisted relative to the top end of the tube. What can happen is that, as the apparatus is being lowered into a borehole, and the borehole perhaps imposes its own slight curvature onto the slightly curved tubes, the bottom end-fitting 30 might suddenly flip through 180 degrees.

[0046] It can happen that the sample-transfer pipe 43, being not mechanically connected to the outer-tube 49, does not follow this rotation. In that case, effectively, the bottom end of the bladder-tube 20 has been twisted relative to its top end. (The bladder-tube 20 itself has no resistance to being twisted.) The bladder-tube 20 is of the order of only a metre or so long, whereby a 180 degree twist in the bladder tube can be quite disruptive to the operational integrity of the bladder.

[0047] The problem can be solved by locking the upper end-fitting at the upper end of the bladder to the adapter, and thus to the outer pump tube 34. The outer pump tube, being only a metre or so long, has a very strong resistance to being twisted. Thus, where the upper-end fitting is locked, torsionally, to the adapter, effectively the bladder is thereby protected from this disruptive twisting.

[0048] As shown in Fig 8, locking the upper-end-fitting of the bladder to the adapter can be done by forming a kink in the long-tube 72, whereby the long-tube now has a friction grip in and to the hollow bore 73 of the adapter 40.

[0049] Now, the outer tube 49 might still undergo a sudden flip through 180 degrees, but now, the upper end of the bladder is constrained to follow that motion. That is to say, the sample-transfer-tube 43 now suffers the twist through 180 degrees; but, being long, the sample-transfer-tube is easily able to accommodate this.

[0050] The kink in the long-tube 72 is so shaped as to leave ample room for gas or liquid to pass through from the annular space 54 to the annular space 56, whereby the kink does not interfere with the ability to pressurise the annular space 56 from the surface.

Claims

Claim 1. Apparatus that includes a tube in combination with an end-fitting, wherein:
[2] the tube has a tube-wall of thin flimsy flexible heat-shrinkable material;
[3] the end-fitting is of hard rigid material;
[4] the end-fitting has a protruding stem, over which the tube is attached;
[5] the stem is provided with a helical groove;
[6] the apparatus includes a helical coil spring;
[7] the spring is dimensionally related to the thickness of the tube-wall and to the groove such that:-
[8] - when an end-portion of the tube is in place on the stem, around the thread-form, the spring can be threaded along the thread-form, over the end-portion of the tube, without damage being caused to the tube-wall; and
[9] - when the spring is threaded over the end-portion of the tube, over the thread-form, the tube-wall lies pinched and compressed radially between the thread-form and the spring, the degree of compression being heavy enough to hold the tube in place against a substantial axial force, and to seal the tube to the stem, when the tube is inflated /deflated by a substantial pressure differential between the inside and the outside of the tube.

Claim 2. Apparatus of claim 1, being an apparatus that was constructed by the following procedure:-
[2] - placing the end-portion of the tube over the stem;
[3] - then heat-shrinking the end-portion down onto the stem;
[4] - then winding the spring along the tube, over the end-portion, pinching the end-portion between the spring and the stem.

Claim 3. Apparatus of claim 1, wherein:
[2] the apparatus comprises a bladder-pump for extracting a sample-volume of a liquid, such as water, from a borehole in the ground, and for conveying the sample-volume to the surface;
[3] and the tube of the apparatus comprises a bladder-tube of the bladder-pump.

Claim 4. Apparatus of claim 3, wherein:
[2]. the device includes an entry-port, which connects the interior of the bladder-tube to the liquid in the borehole;
[3] the bladder-pump has a lower-check-valve, so arranged in the entry-port that liquid can enter the bladder-tube from the borehole only when the pressure in the bladder-tube is less than the pressure in the borehole;
[4] the apparatus includes a sample-transfer-pipe, which connects the interior of the bladder-tube to the surface;
[5] the bladder-pump has an upper-check-valve, so arranged that liquid in the

bladder-tube can pass upwards in the sample-transfer-pipe to the surface only when the pressure inside the bladder-tube exceeds the pressure in the sample-transfer-pipe;

[6] the apparatus includes an outer-pump-tube, which encircles the bladder-tube, creating an annular-space therebetween;

[7] the apparatus includes an operable pressure-controller, at the surface;

[8] the pressure-controller is effective, when operated, to manipulate the pressure in the annular-space such that the bladder-tube is alternately inflated and deflated, whereby liquid from the borehole is pumped to the surface.

Claim 5. Apparatus of claim 4, wherein the outer-pump-tube has an internal diameter of less than fifteen mm.

Claim 6. Apparatus of claim 4, wherein the end-fitting comprises an upper-bladder-end-fitting;

[2] the stem is formed on the upper-bladder-end-fitting;

[3] the sample-transfer-pipe is physically coupled to the upper-bladder-end-fitting, which is structured for conveying liquid from inside the bladder-tube into the sample-transfer-pipe;

[4] the upper-bladder-end-fitting and the bladder-tube lie suspended mechanically from the sample-transfer-pipe, to the extent that the upper-bladder-end-fitting can float vertically relative to the outer-pump-tube.

Abstract of the Disclosure

Title: BLADDER PUMP FOR BOREHOLE SAMPLING

The bladder, of flimsy ptfe tubing, is attached to the stem of an end-fitting. The stem is formed with a helical screw-thread form. The tubing is heat-shrunk down over the stem. Then, a helical coil spring is screwed onto the form, whereby the thickness of the ptfe tubing lies trapped and squeezed between the stem and the spring. This manner of attaching the bladder to the stem is mechanically adequate even when the bladder tubing is of small diameter.

Anthony Asquith
Agent for the Applicant
Docket: 407-89

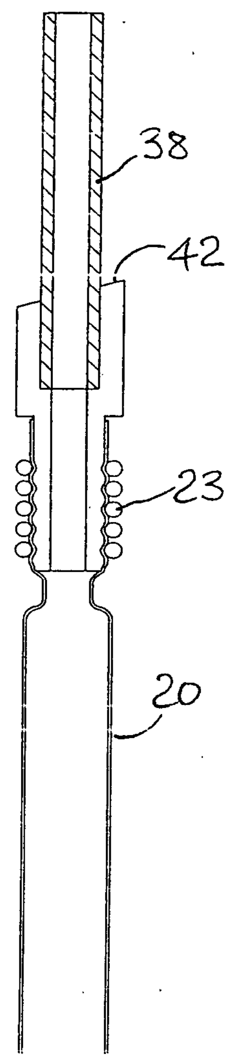

FIG 3

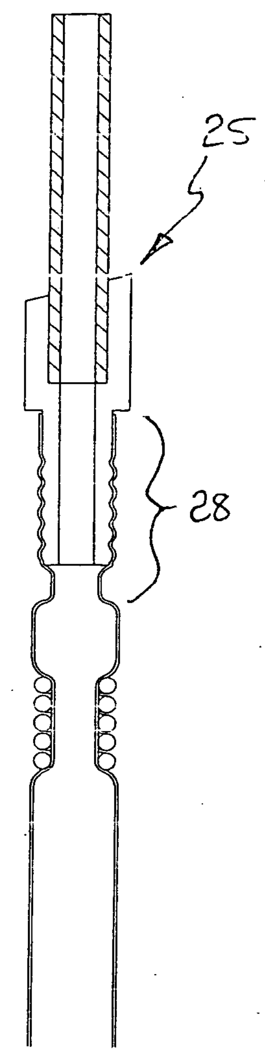

FIG 2

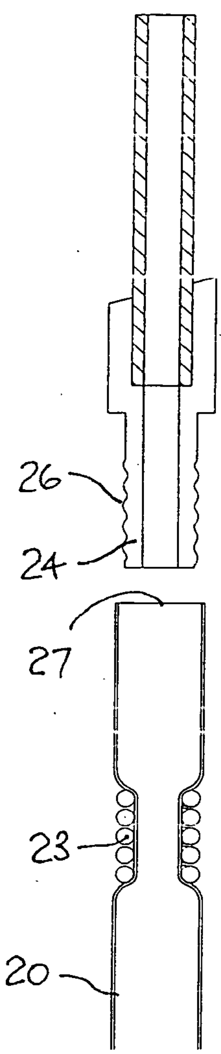

FIG 1

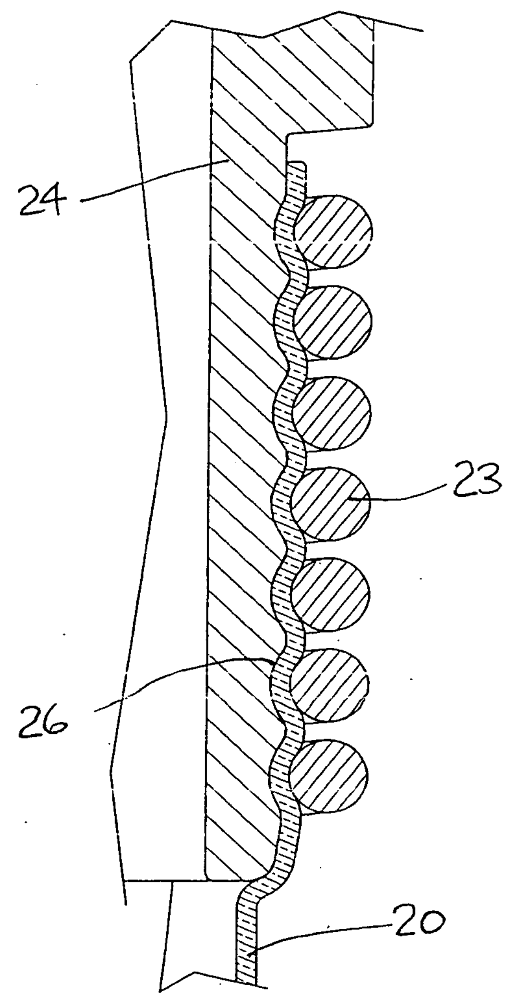

FIG 4

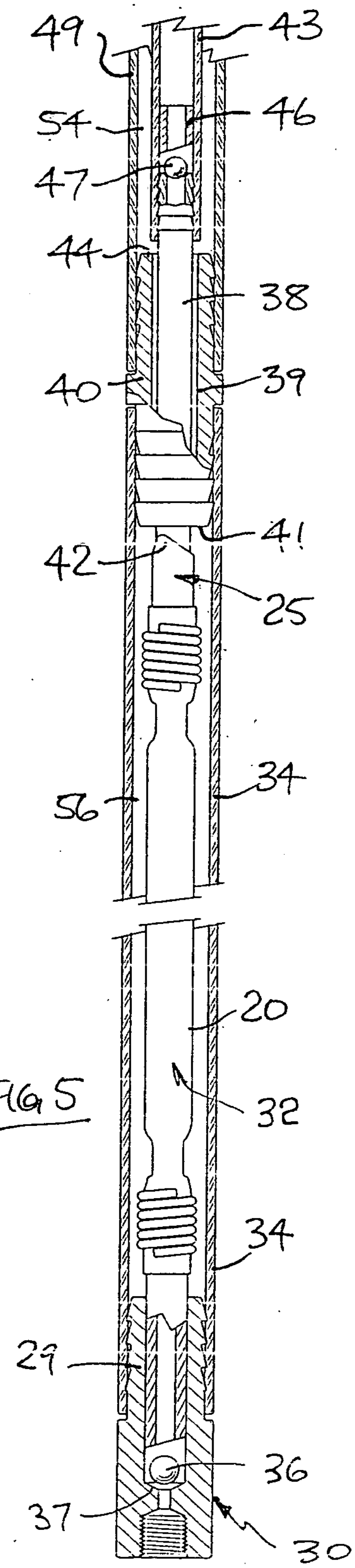

FIG 5

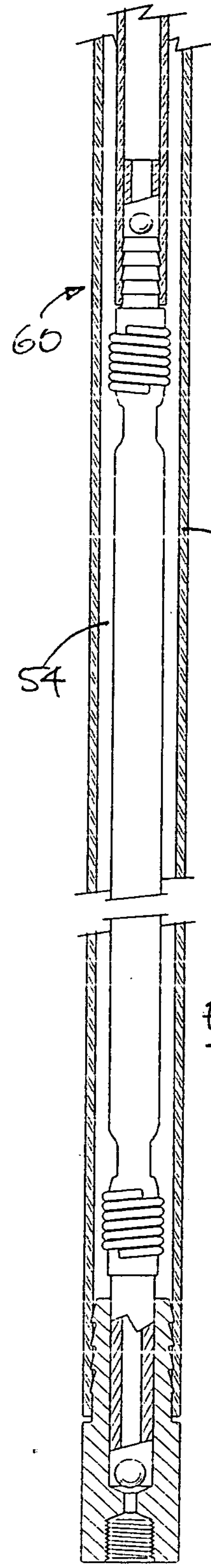

FIG 7

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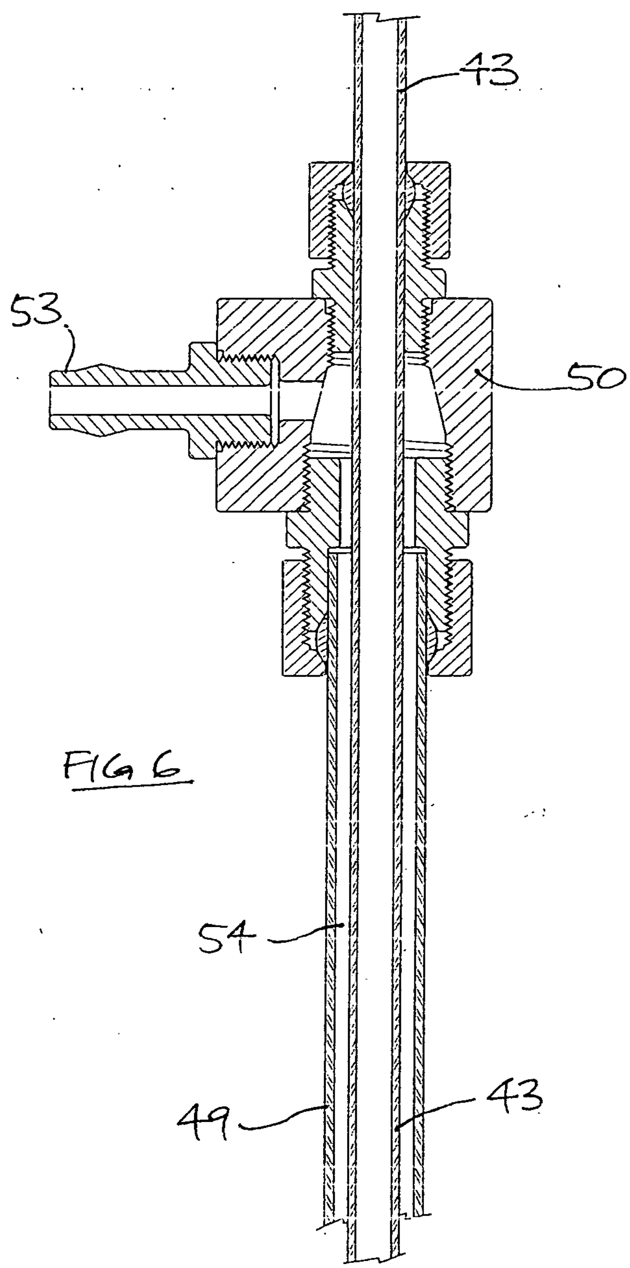
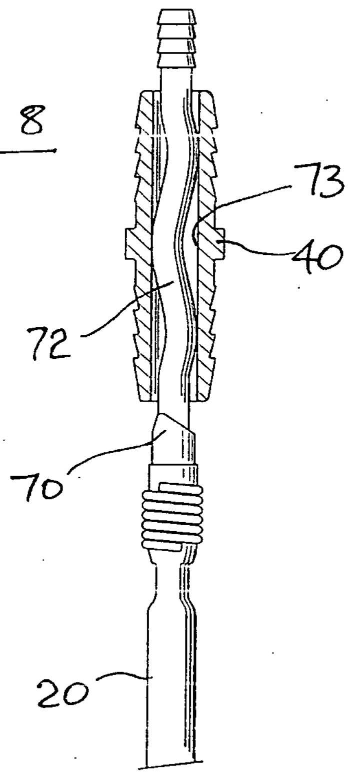


FIG 6

FIG 8



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